Statistical Thinking

- What is statistics, anyway?

Statistics

- The science of collecting, organizing, summarizing, and analyzing data to answer questions and/or draw conclusions.

Why statistics?

- To satisfy our curiosity
  - Exploring the world around us.
  - Searching for patterns to lead to discoveries
- To make sure that we can stand on our legs
  - Evidence to show that we are right (or wrong)

Statistics Rests on Two Major Concepts

- Variation
  - Differences or changes in an item

Statistics Rests on Two Major Concepts

- Data
  - Observations gathered to draw conclusions
  - Context matters

Context matters –Always Ask:

total example

@ 00:50:00

- Who: Describe the individuals who were surveyed.
- What: Determine what is being measured.
- When: When was the research conducted?
- Where: Where was the research conducted?
- Why: What was the purpose of the survey or experiment?
- How: Describe how the survey or experiment was conducted.

Introduction to Data Science: What makes a good data scientist?

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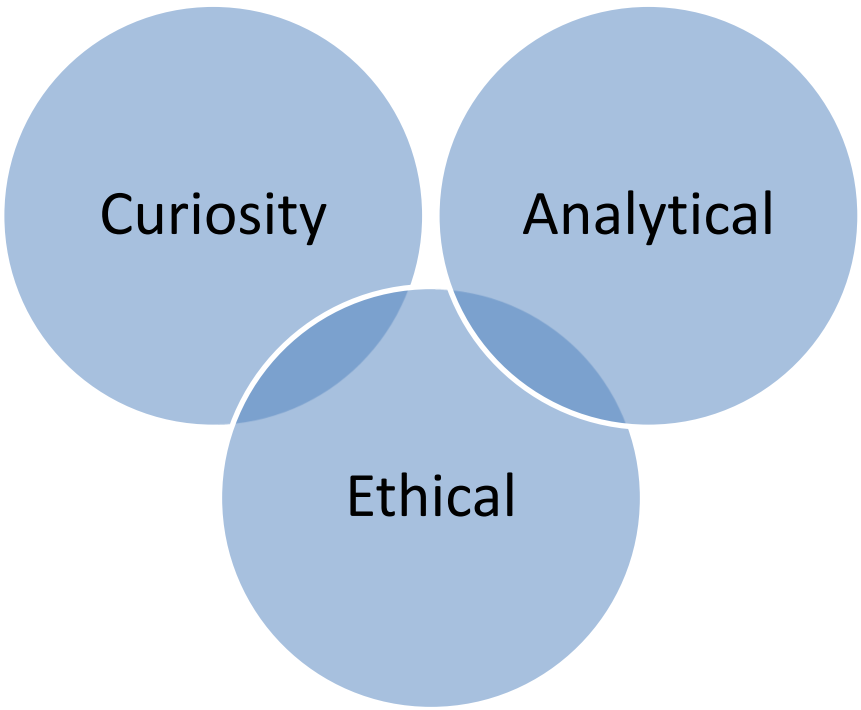
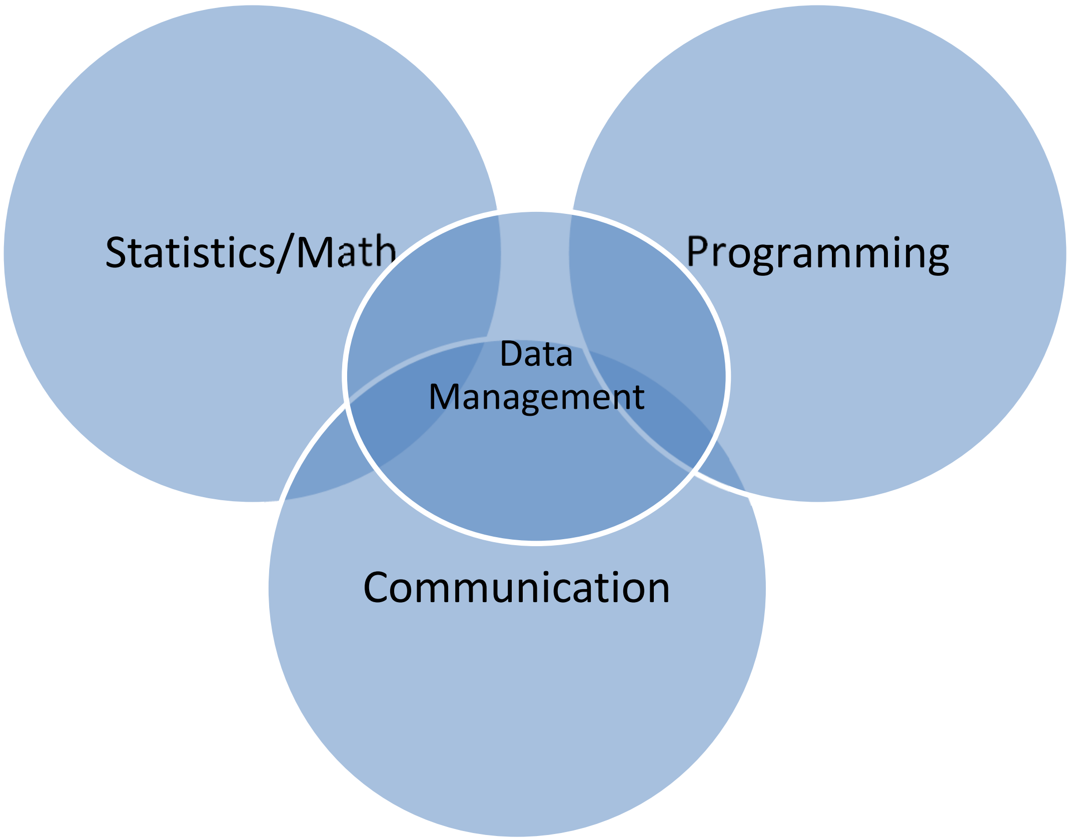


Introduction to Data Science: What makes a good data scientist?



Introduction to Data Science: Data Science Terminology

Introduction to Data Science: Data Science Terminology

- Data Scientist
- Data Analyst
- Business Analyst
- Data Engineer
- Data Governance
- Data Set
- Data Wrangling
- Data Modeling
- Data Mining
- Data Visualization
- Big Data
- Machine Learning

Statistics: Data Types

Statistics: Data Types

How do you define data?

- Information or a set of values collected from surveys, experiments, observations, etc.

Statistics: Data Types

- In statistics, we classify data into four categories:
  - Nominal Data
  - Ordinal
  - Interval
  - Ratio

Statistics: Data Types

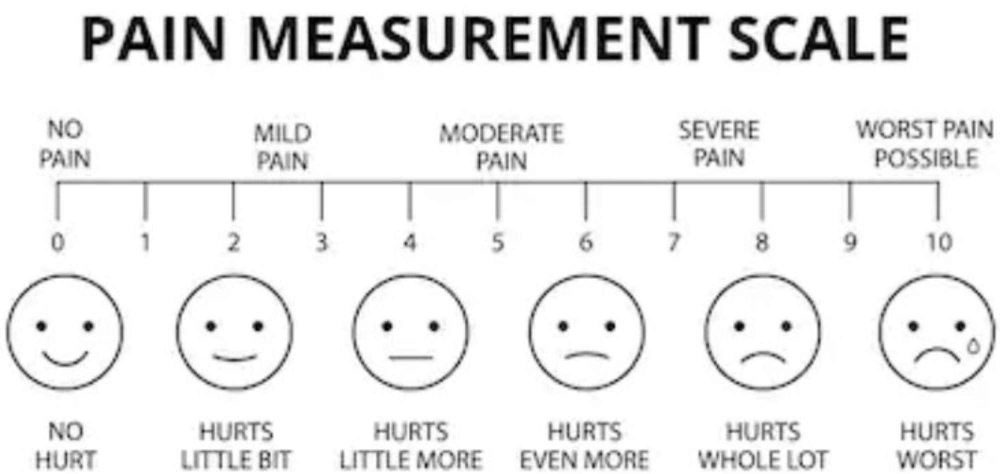
- Nominal Data
  - Labels; no quantitative value; can be grouped

Statistics: Data Types

- Nominal Data
  - Labels; no quantitative value; can be grouped

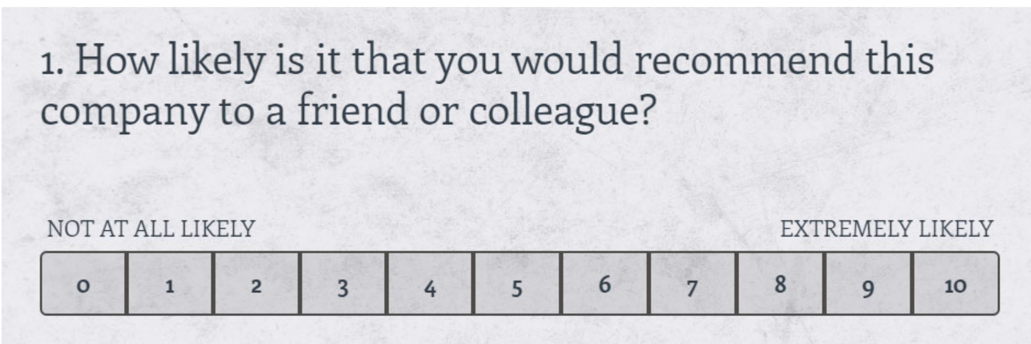
Statistics: Data Types

- Ordinal
  - Non-numerical values; can be ranked



Statistics: Data Types

- Ordinal
  - Non-numerical values; can be ranked



Statistics: Data Types

- Interval
  - Numerical values; equal distance between; known order and differences

Statistics: Data Types

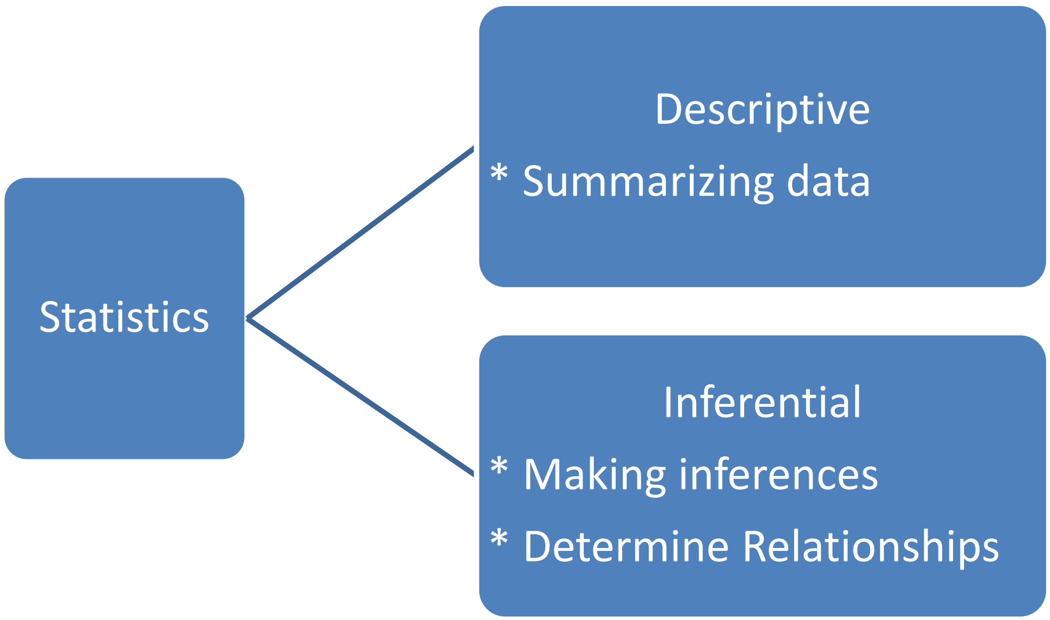
- Interval
  - Numerical values; equal distance between; known order and differences

Statistics: Data Types

- Ratio
  - Can be compared

Statistics

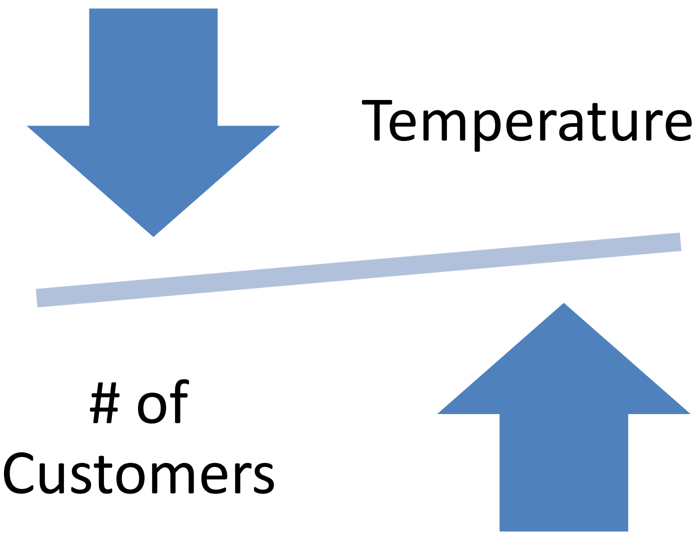
Statistics


Statistics
Descriptive
* Summarizing data
Inferential
* Making inferences
* Determine Relationships

Statistics

Temerature	Number of Customers		
	Day 1	Day 2	Day 3
90	100	80	90
80	200	180	215
70	300	260	295
60	160	180	170
50	50	50	49
40	10	9	8

Statistics



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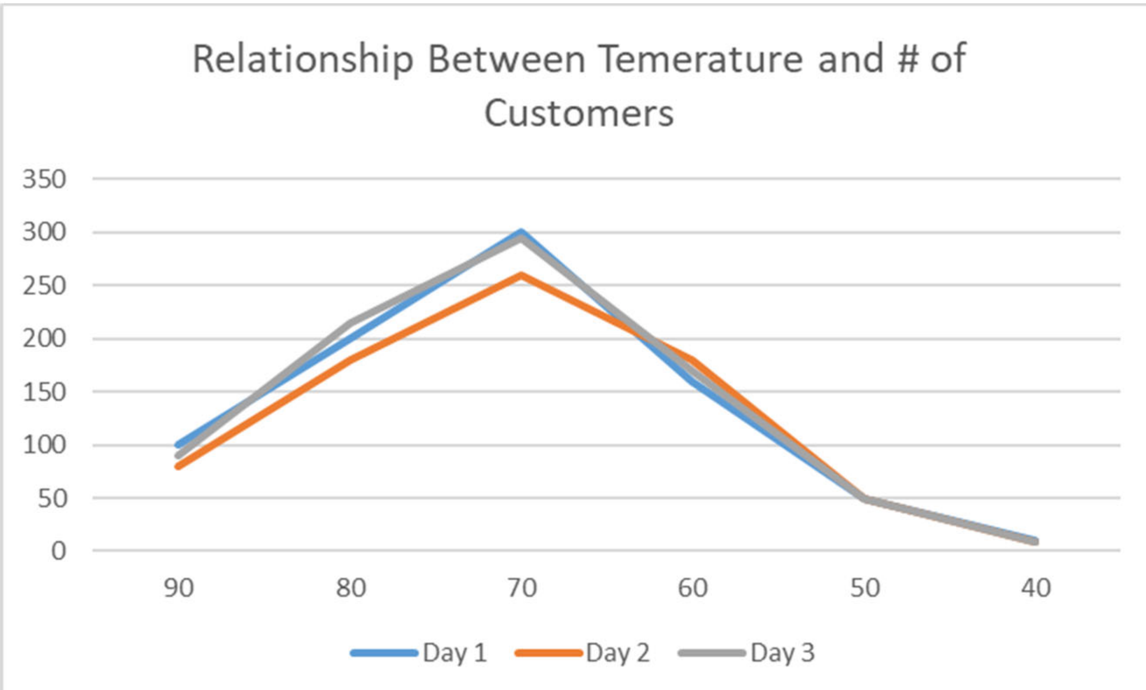

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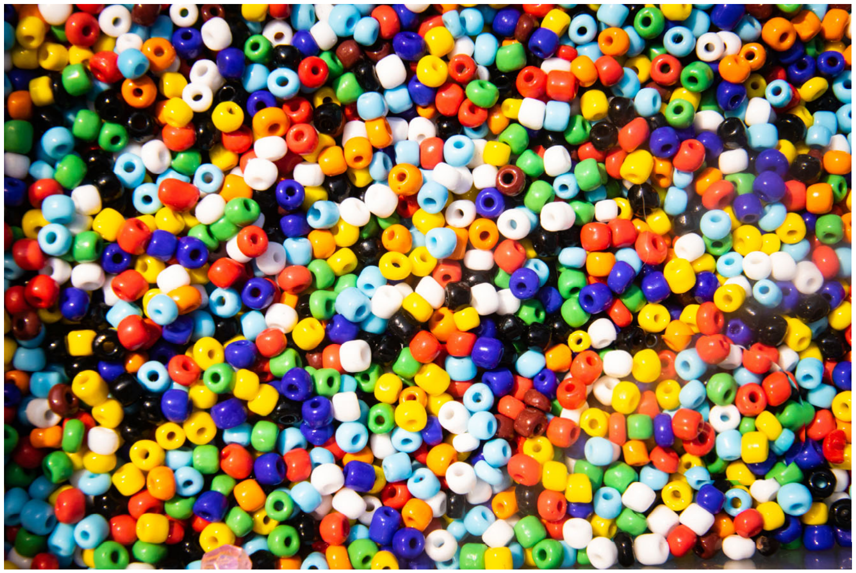
Statistics

- Descriptive Statistics
  - Describe data
- Inferential Statistics
  - Describe and infer

Module 1 Video 3: Statistics



Population

- The entire set (of interest)

Sample

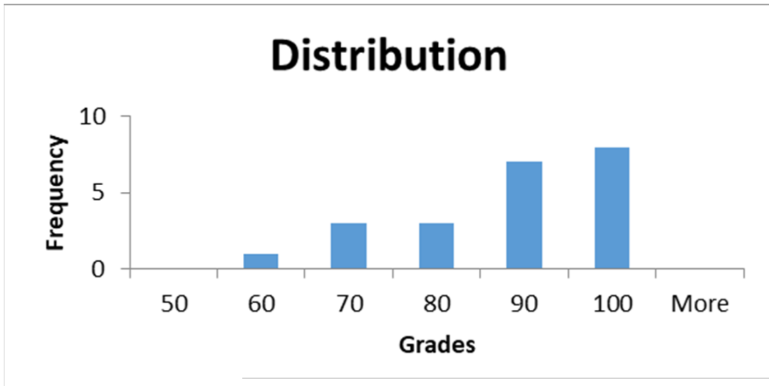
- A subset of a Population

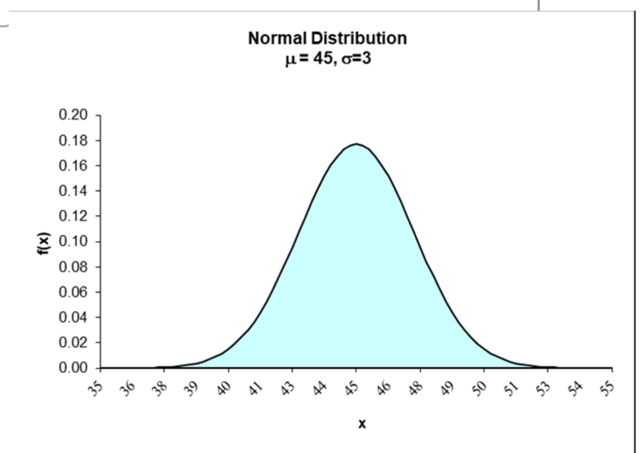
Random

- all items have equal chance to be selected

Statistics: Central Tendency

Statistics: Central Tendency

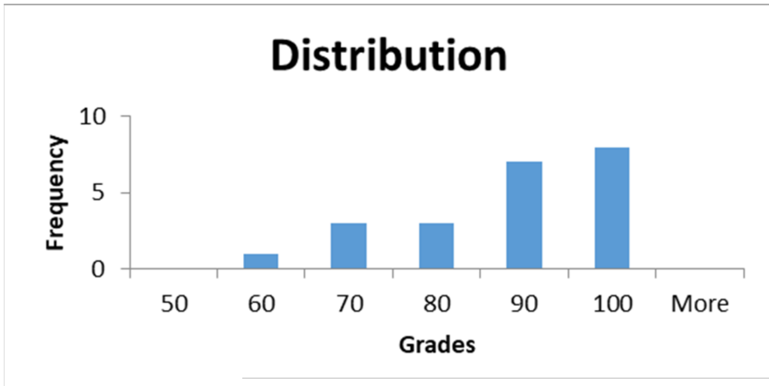


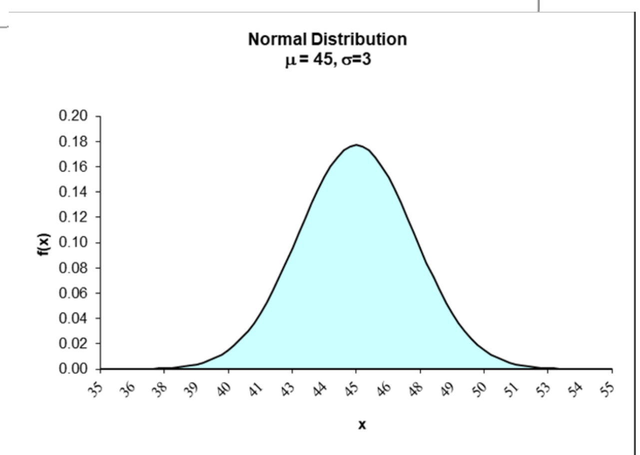


Distribution:

- Shows all values in a data set and their frequency

Statistics: Central Tendency





Central Tendency: a value describes the center or central location of a data set.

- There are three ways to describe the central tendency: mean, median, and mode.

Statistics: Central Tendency

Mean

- Numerical average of the data set

Congratulations!
Your test score is
80!

Statistics: Central Tendency

Mean (μ mu)

Studens	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Grades	90	98	56	67	89	78	98	100	64	89	98	76	95	100	90	85	78	95	86	89	91	67

Population mean = $\mu = (\Sigma X_i) / N$

Where Σ = the sum of

X_i = individual datum value

N = the number of datum in the population

(90+ 98+ 56+ 67+ 89+ 78+ 98+ 100+
64+ 89+ 98+ 76+ 95+ 100+ 90+ 85+
78+ 95+ 86+ 89+ 91+ 67) **/ 22 = 85.4**

Statistics: Central Tendency

Mean ($\bar{x}$ x bar)

Sample mean $\bar{x} = (\Sigma x_i) / n$

Where Σ = the sum of

x_i = individual datum value

n = the number of datum in the sample

Median

- Score at 50 percentile; the number in the middle

Congratulations!
Your test score is
80!

Statistics: Central Tendency

Median

Studens	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Grades	90	98	56	67	89	78	98	100	64	89	98	76	95	100	90	85	78	95	86	89	91	67

First, we have to rank order the numbers

Studens	C	I	D	V	L	F	Q	P	S	E	J	T	A	O	U	M	R	B	G	K	H	N
Grades	56	64	67	67	76	78	78	85	86	89	89	89	90	90	91	95	95	98	98	98	100	100

Since there are two numbers in an even size data set, we will add the 2 numbers then divide the sum by 2 to obtain the median

$$(89+89) / 2 = 89$$

Statistics: Central Tendency

Median

Coffee 3.25 5.25 5.25 3.55 4.95

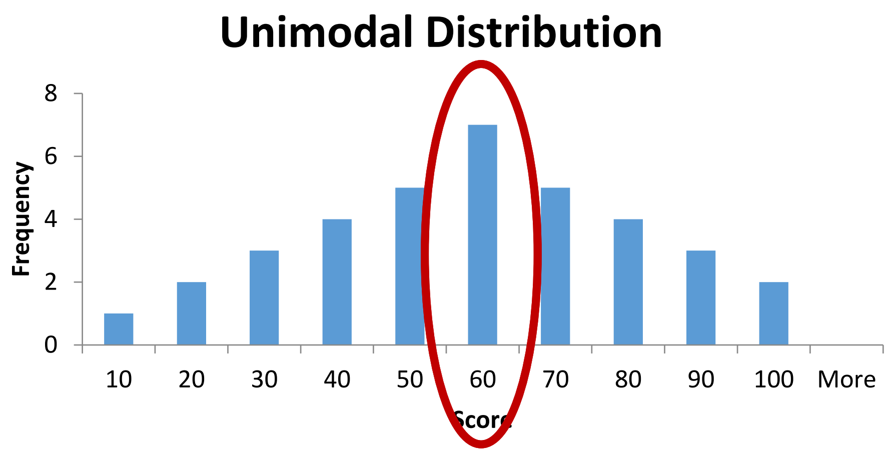
First, we have to rank order the numbers

Coffee 3.25 3.55 4.95 5.25 5.25

$4.95 is the median

Mode

- The most frequently occurring; the most common



Mode

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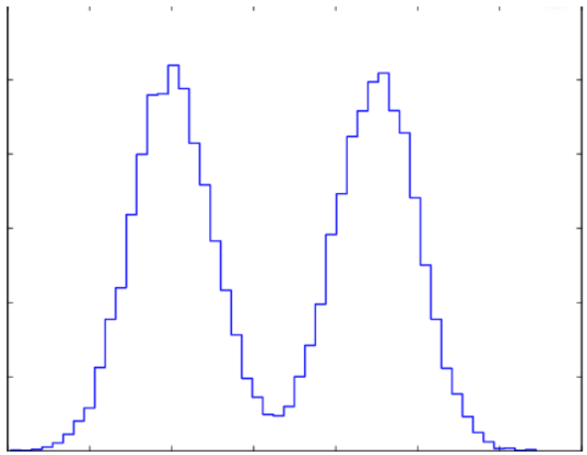


Bimodal Distribution

Statistics: Central Tendency

Mode

- The most frequently occurring; the most common

2	2	3	3	4	4	4	4	4	5	5	5

2	2	3	3	3	4	4	5	6	7	7	8	8	8	9	9	10	11	12	12

Statistics: Central Tendency

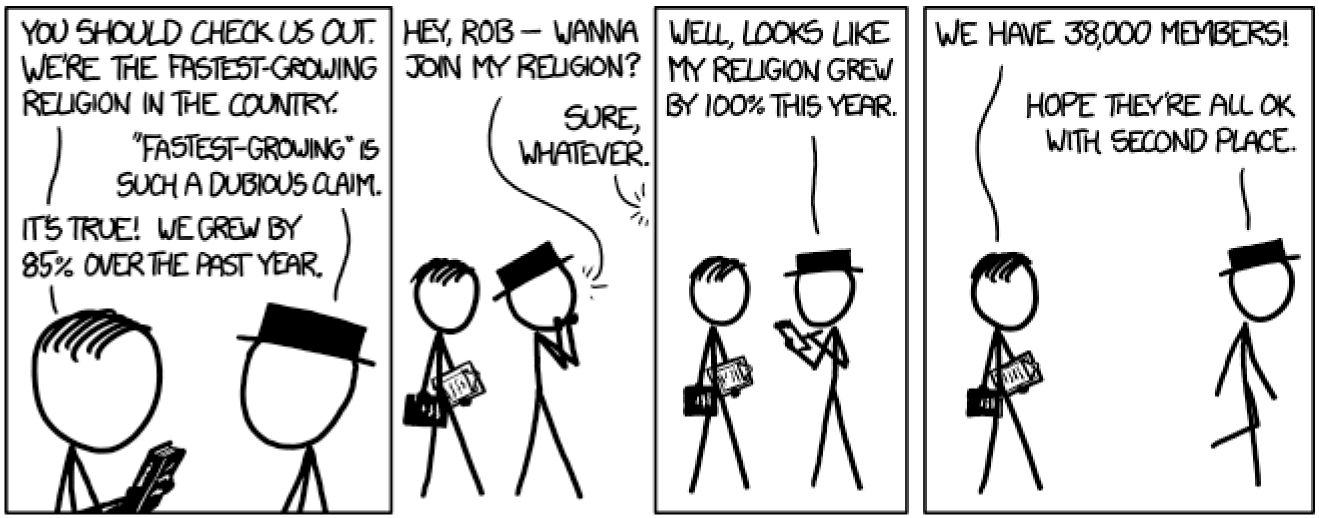
Statistics: Misleading Stats

?

Statistics: Misleading Stats

Statistics: Misleading Stats

Statistics: Misleading Stats



Statistics: Central Tendency 2: Mode, Mean, Median – Which One?

Statistics: Central Tendency

- Mode
  - Nominal data – outliers are fine
    - Which brand do you prefer?
- Mean
  - Interval and ratio data not excessively skewed
    - What is the average salary?
- Median
  - Ordinal Data – skewed data is fine
    - How satisfy are you?

Statistics: Central Tendency

Statistics: Standard Deviation and Variance

Spread of data

Statistics: Standard Deviation and Variance

- Standard Deviation
  - Average distance from the mean

Statistics: Standard Deviation and Variance

- Standard Deviation (Population)

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where σ = lowercase sigma = standard deviation

Σ = the sum of

Xi = individual datum value

μ = mean of population

N = the number of datum in the population

Statistics: Standard Deviation and Variance

- Standard Deviation (Population)
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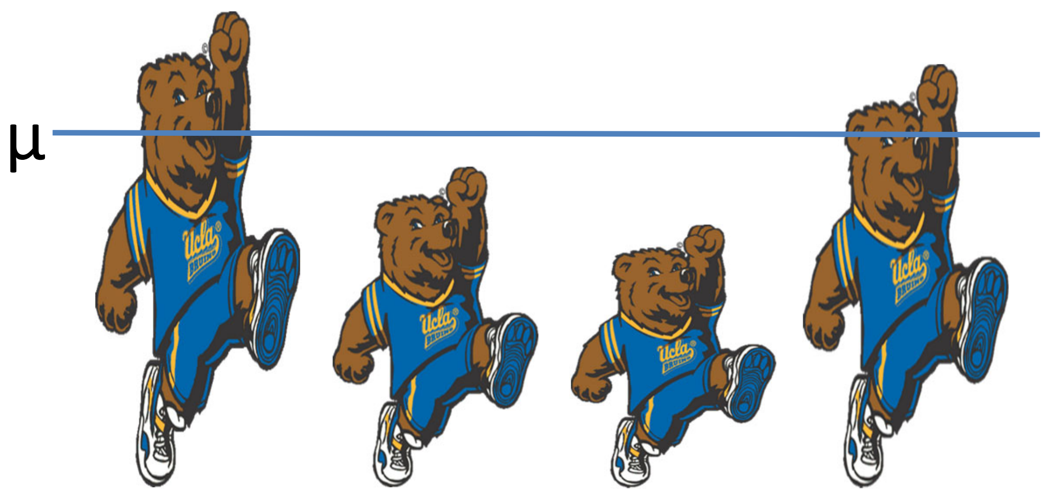

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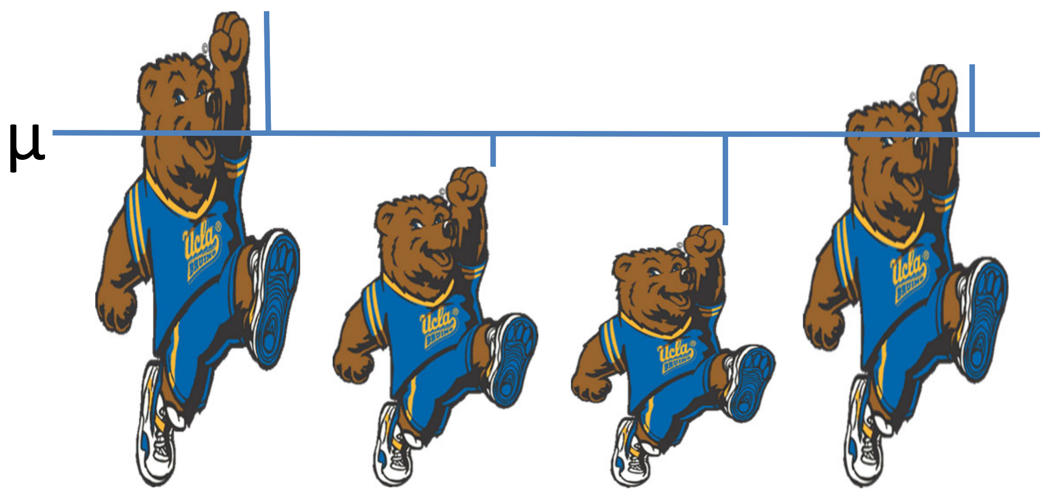

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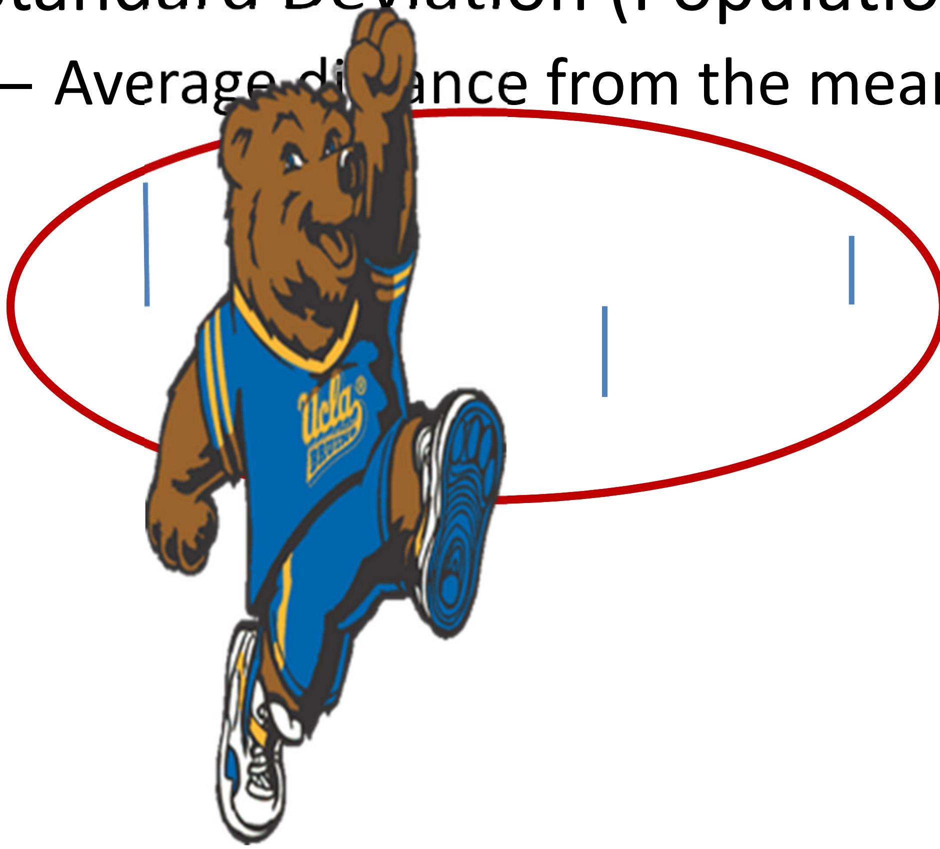


Statistics: Standard Deviation and Variance

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

- Standard Deviation
  - Price of Ice Tea **(1, 3, 6, 8, 7)**
    - N = 5
    - μ = (1+3+6+8+7)/ 5 = 5

$$\sigma = \sqrt{\frac{(1-5)^2 + (3-5)^2 + (6-5)^2 + (8-5)^2 + (7-5)^2}{5}}$$

$$\sigma = \sqrt{\frac{16+4+1+9+4}{5}} = \sqrt{\frac{34}{5}}$$

$$\sigma = \sqrt{\frac{34}{5}} = \sqrt{6.8} = \boxed{2.61}$$

Statistics: Standard Deviation and Variance

- Standard Deviation (Sample)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Where s = standard deviation (sample)

Σ = the sum of

xi = individual datum value

x̄ = mean of sample

N = the number of datum in the population

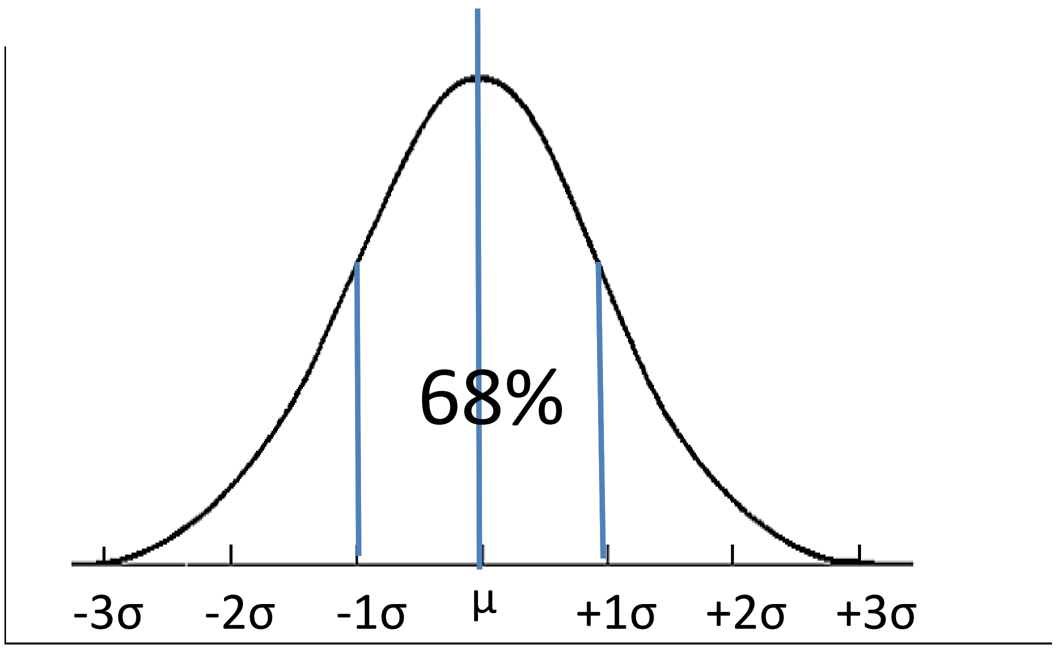
Statistics: Standard Deviation and Variance

- Variance (Population) = σ^2
- Variance (Sample) = s^2

Statistics: Standard Deviation and Variance

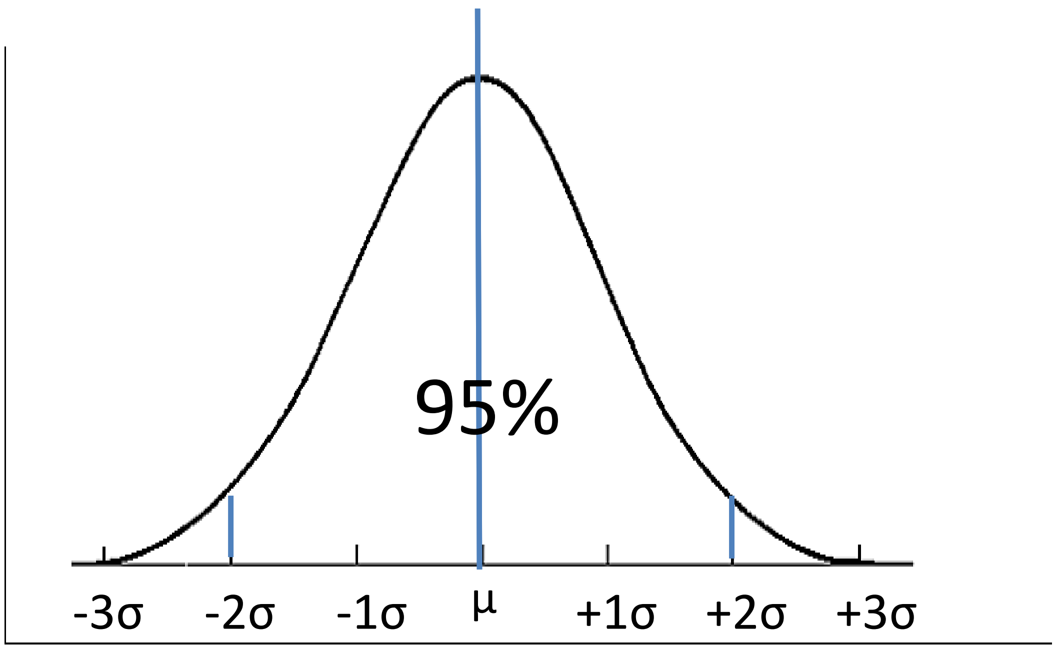
Statistics: Standard Deviation and Variance Empirical Rule

Statistics: Standard Deviation and Variance Empirical Rule



- Standard Deviation
  - 68–95–99.7 rule
  - Empirical Rule

Statistics: Standard Deviation and Variance Empirical Rule



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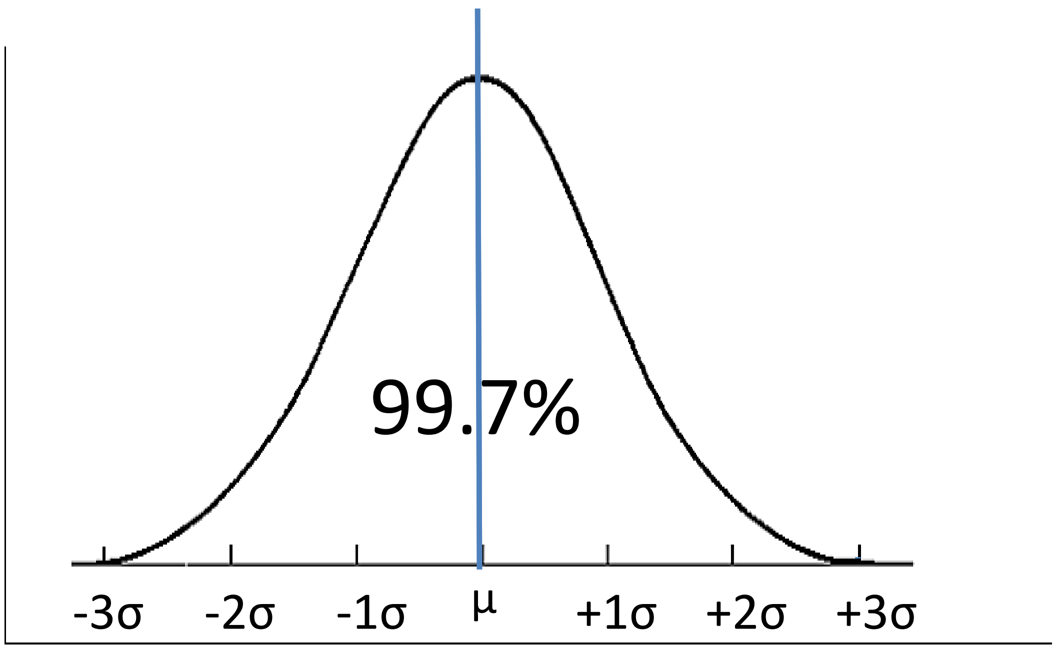
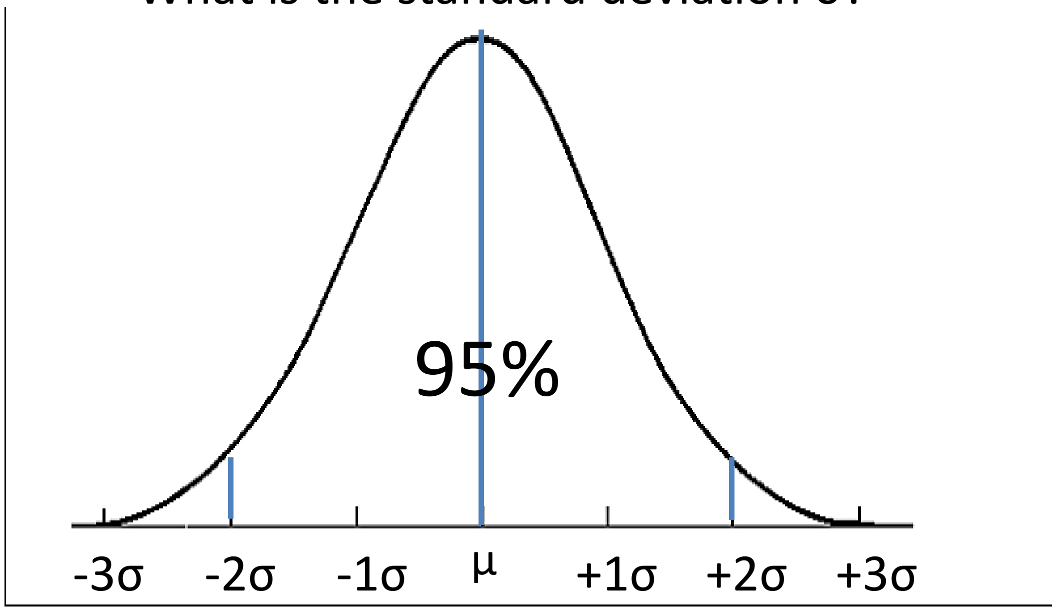


- Standard Deviation
  - 68–95–99.7 rule
  - Empirical Rule

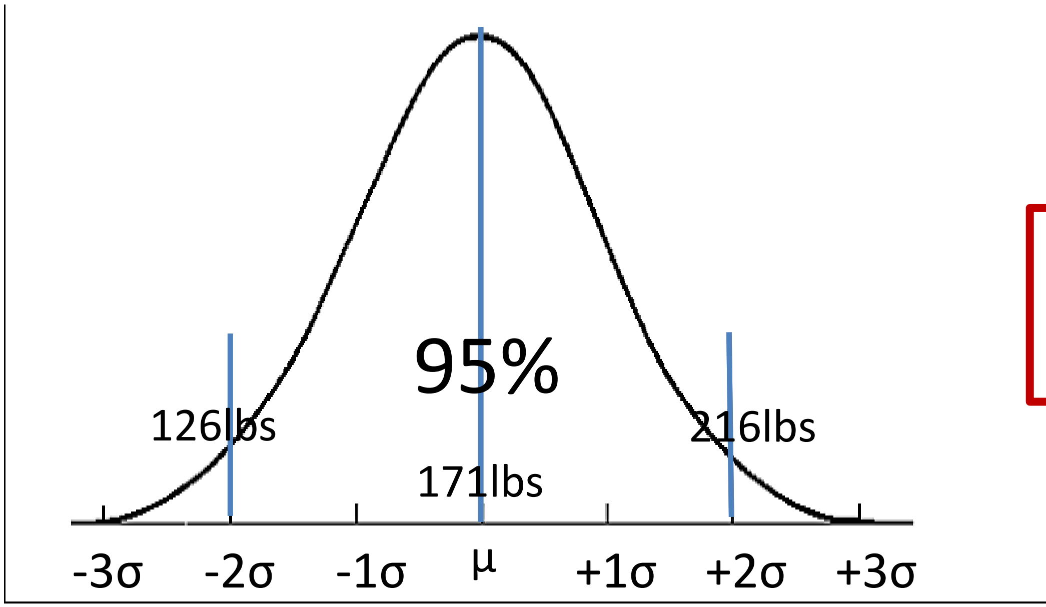
Statistics: Standard Deviation and Variance Empirical Rule

- Standard Deviation
  - U.S. males average weight is 171 pounds. A 95th percentile male is 216 pounds
  - What is the standard deviation σ?

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$



Statistics: Standard Deviation and Variance Empirical Rule



$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

95 Percent males in the United States weight between 126lbs and 216lbs with a standard deviation of 22.5lbs

σ = ?

μ = 171 lbs

A 95 percentile male is 216 lbs (95 percentile is 2 standard deviation from mean)

σ = (216 -171)/2; **σ = 22.5**

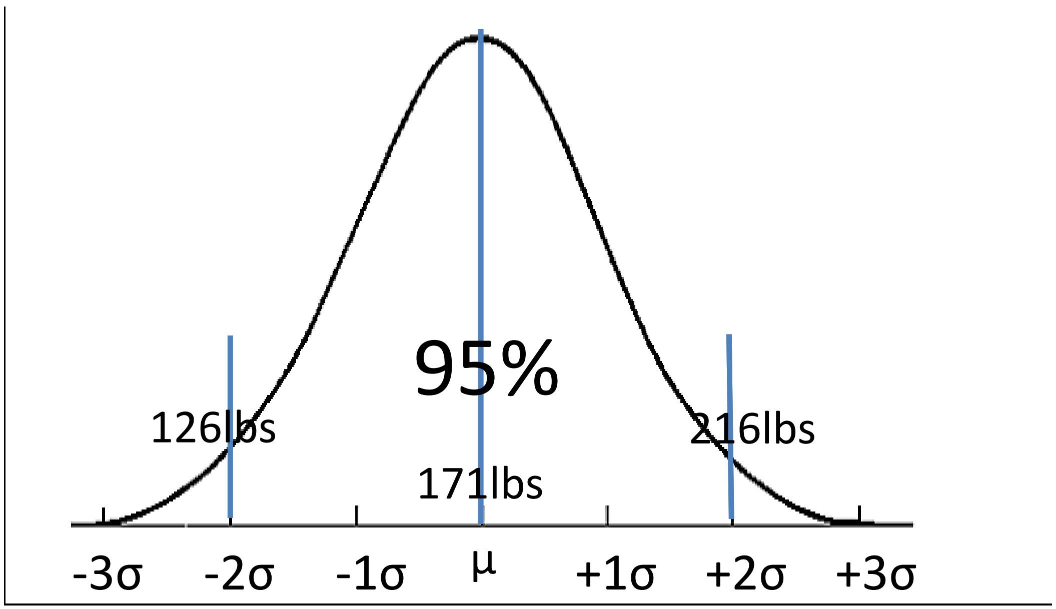
Statistics: Standard Deviation and Variance Empirical Rule

Statistics: Z-Score

Z-score

- Describes the location of a raw value in relations to the mean and standard deviation

Statistics: Z-Score for Population



$$Z_X = (X - \mu) / \sigma$$

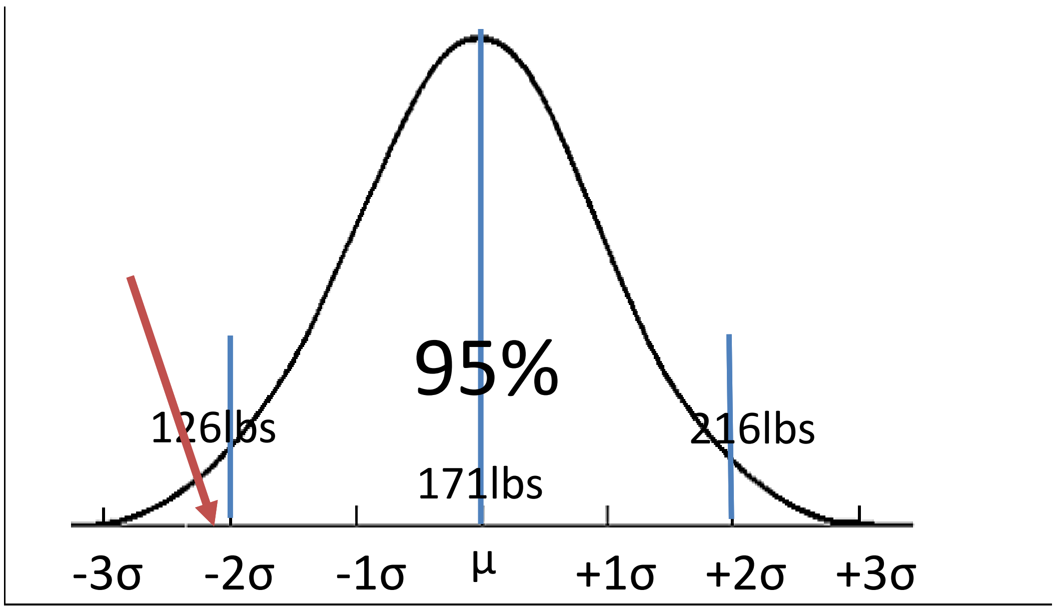
σ = ?

μ = 171 lbs

A 95 percentile male is 216 lbs (95 percentile is 2 standard deviation from mean)

$\sigma = (216 - 171)/2$; $\boldsymbol{\sigma = 22.5}$

Statistics: Z-Score for Population



σ = ?

μ = 171 lbs

A 95 percentile male is 216 lbs (95 percentile is 2 standard deviation from mean)

$\sigma = (216 - 171)/2$; $\boldsymbol{\sigma = 22.5}$

What is the Z-Score for 120lbs?

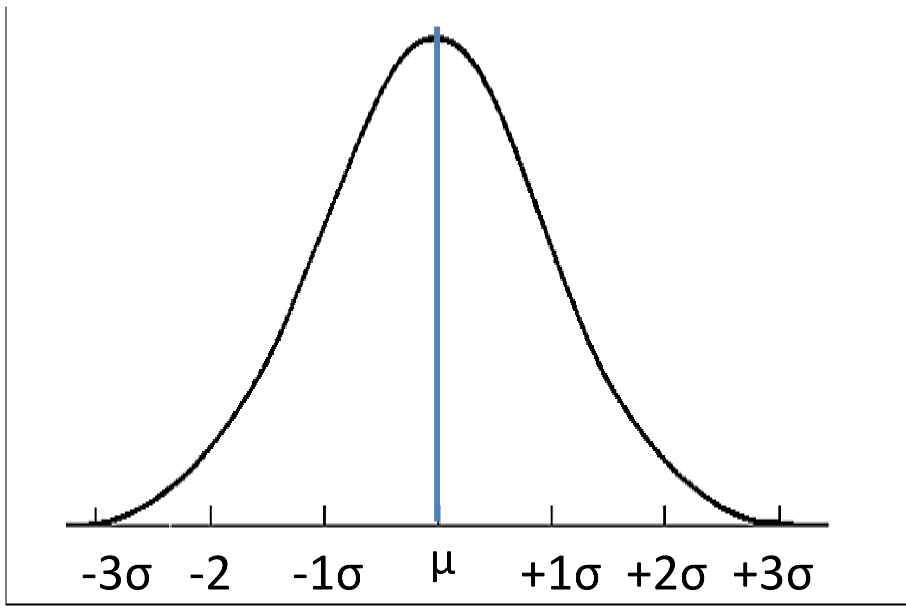
$Z_X = (X - \mu) / \sigma$

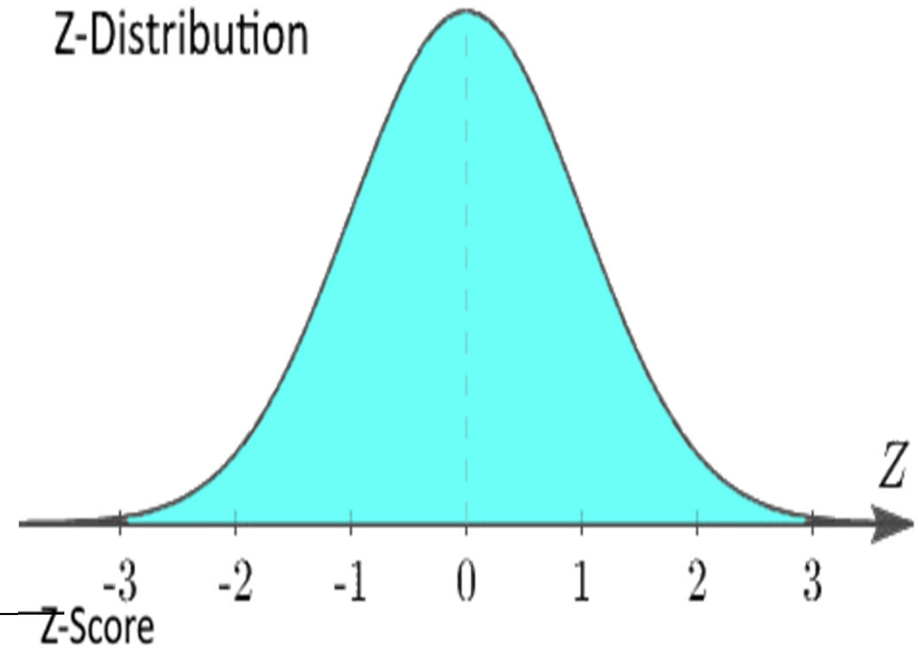
$Z_{120} = (120 - 171) / 22.5$

$\mathbf{Z_{120} = -2.27}$

- a 120lbs male is 2.27 standard deviation from the mean

Statistics: Z-Score for Population





Normal Distribution → Standard Normal Distribution

$\sigma = 1$

$\mu = 0$

Statistics: Z-Score for Sample

$$z_x = (x - \bar{x}) / s$$

Statistics: Z-Score

Statistics: z-Distribution and t-Distribution

In the context of sample size

Statistics: z-Distribution and t-Distribution

- Standard Deviation (Population)

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where σ = lowercase sigma = standard deviation
Σ = the sum of
Xi = individual datum value
μ = mean of population
N = the number of datum in the population

Statistics: Standard Deviation and Variance

- Standard Deviation (Sample)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Where s = standard deviation (sample)

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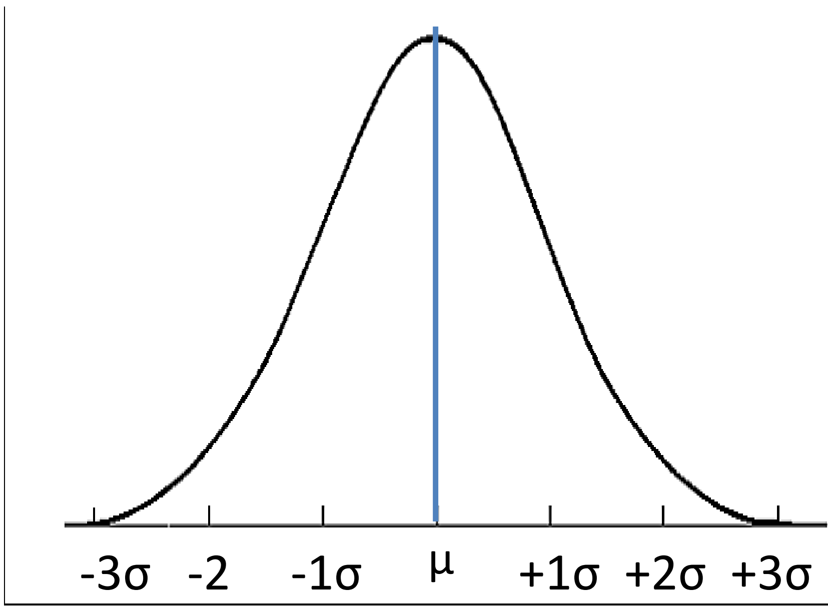
x̄ = mean of population

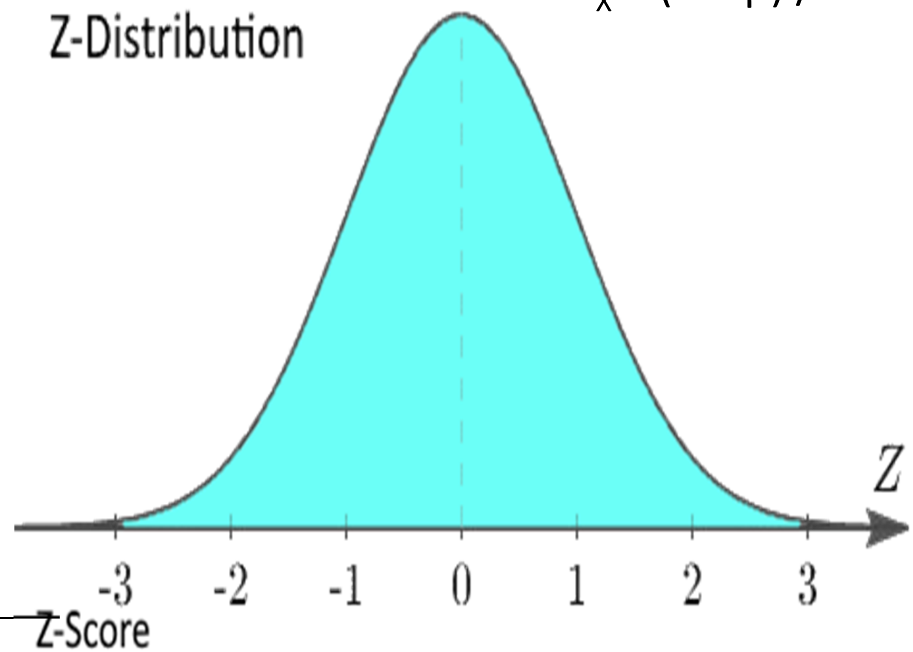
N = the number of datum in the population

Statistics: z-Distribution and t-Distribution



Normal Distribution

$Z_X = (X - \mu) / \sigma$

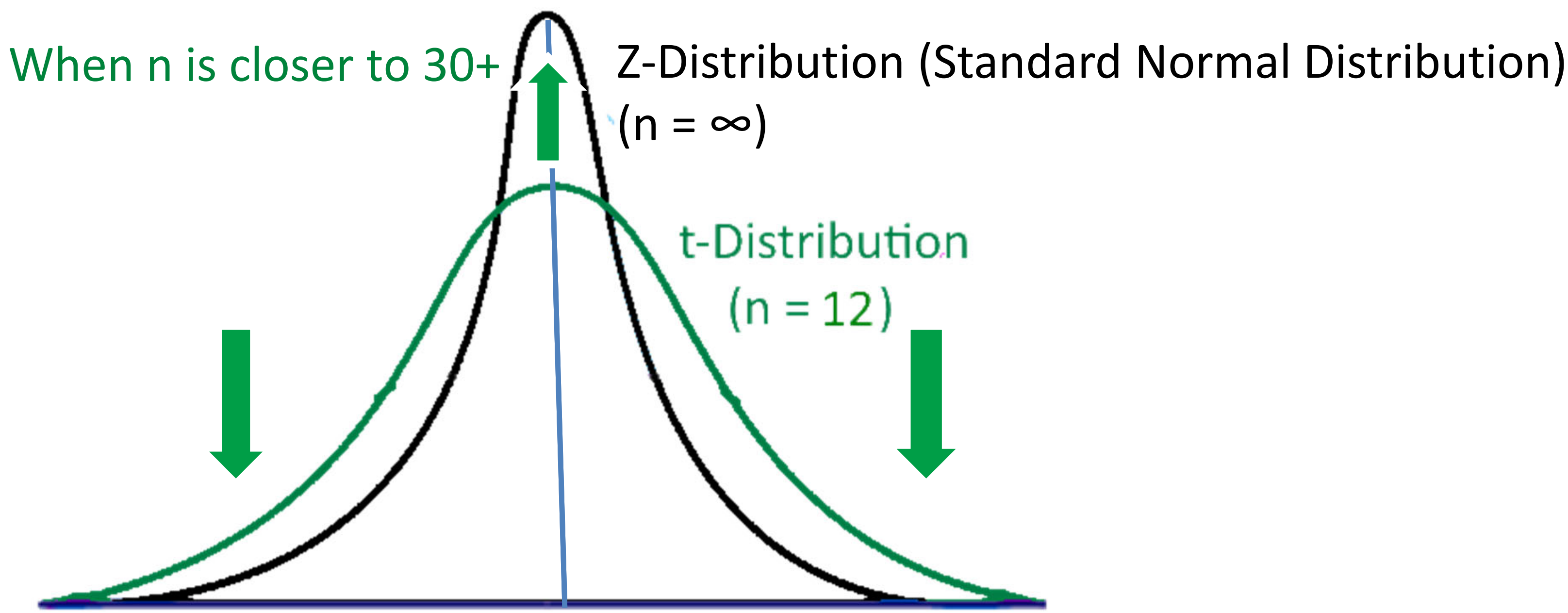


Standard Normal Distribution

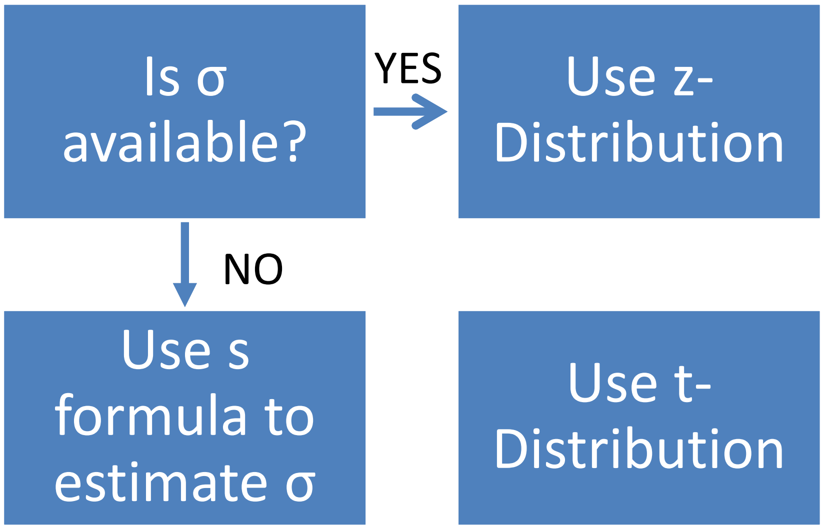
$\sigma = 1$

$\mu = 0$

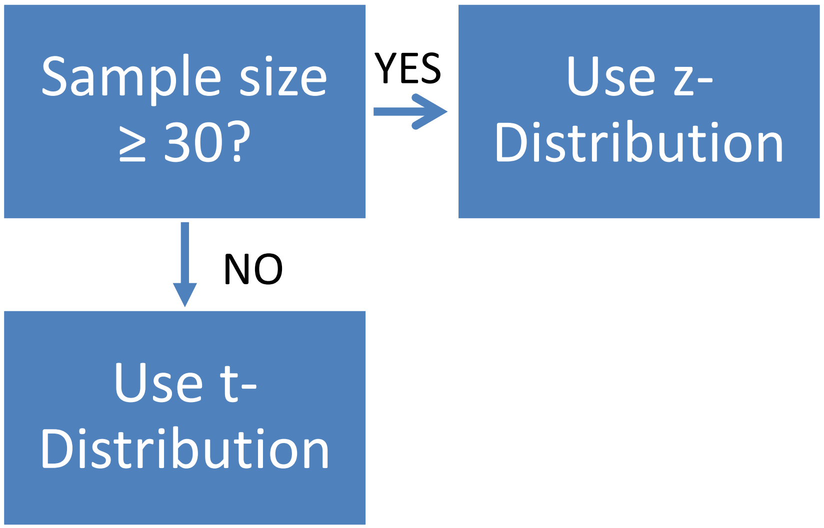
Statistics: z-Distribution and t-Distribution



Statistics: z-Distribution and t-Distribution



Statistics: z-Distribution and t-Distribution



Statistics: z-Distribution and t-Distribution